

**DIETARY FIBER INTAKE AND ITS RELATIONSHIP TO CHILDHOOD
OBESITY**

A Thesis Proposal

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By

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Problem Statement

Obesity, a condition of excess body fat, is classified by having a Body Mass Index, (BMI) $> 30 \text{ kg/m}^2$. BMI is a number calculated from a person's weight and height and generates a reliable indicator used to categorize an individual's weight to screen for their risks of potential health problems. In the late 1800s in the United States, only 3% of adults were considered overweight and obese, whereas approximately 34% of adults are obese today. However, obesity is also a common problem among children and adolescents in addition to adults. Within the past 20 years, the incidence of overweight children has doubled and the number of overweight adolescents has tripled (1). In the United States where childhood obesity is often referred to as an epidemic, approximately 2.5 million children and adolescents between 2-19 years of age are classified according as obese according to their BMI (2). However, the obesity epidemic is not limited to the United States as worldwide incidence of obesity has more than doubled since 1980 (3).

The increasing incidence of obesity causes many individuals to be at a higher risk for developing other health conditions commonly referred to as co-morbidities. Research has shown individuals with a higher BMI value, such as those classified as overweight and obese, are strongly associated with weight-related morbidity and mortality rates (1). Obese children are at a higher risk than healthy weight children of remaining obese throughout adulthood which may lead to conditions causing disability and in some cases even premature death. They also are at risk to suffer from breathing difficulties, increased risk of fractures, hypertension, early markers of cardiovascular disease (CVD), insulin resistance and psychological effects. Children who continue to be obese throughout adulthood are at an even higher risk for developing CVD, type 2 diabetes,

musculoskeletal disorders, and cancer. While mortality from malnutrition is commonly thought to be associated with complications from being underweight, malnutrition also refers to individuals who are over-nourished, specifically overweight and obese individuals. Currently in the United States, a higher percentage of individuals are dying from health complications associated with obesity than mortality associated with being underweight (4).

Obesity is a complex condition caused by many multiple factors including genetics and lifestyle behaviors. In an environment such as the United States where energy dense foods are supplied in abundance and physical activity is generally low, genetic factors influence individuals to be more susceptible to weight gain than others. However, even individuals who are not predisposed to obesity are likely to gain weight over time if they are continually consuming more energy than they are expending on a daily basis. As a result, the impact of lifestyle factors becomes very influential regardless of whether an individual is predisposed to weight gain. Lifestyle factors provide an avenue for individuals to combat their predisposition to gain weight. The top two most common lifestyle factors leading to obesity are poor dietary habits and low levels of physical activity. Dietary habits are comprised of a variety of elements expanding wider than just the specific foods and beverages consumed. Dietary habits also include the nutrient profile of the foods, the frequency of consumption, portion size, and the amount of mineral and vitamins consumed(1).

Improving dietary habits and increasing levels of physical activity are two beneficial changes overweight and obese individuals can integrate to improve their lifestyle behaviors. Achieving and maintaining weight loss require modifying current

lifestyle behaviors including choosing healthy foods and portion sizes and how much physical activity in which to engage. According to the Dietary Guidelines for Americans, a healthy weight-maintenance program includes setting reasonable goals, choosing nutritious foods in moderation, and increasing energy expenditure through physical activity (1). Modifying lifestyle behaviors and decreasing body mass index will eliminate the need for many medical expenses for obese individuals. Currently, the Center for Disease Control estimates \$147 billion is spent annually to treat medical conditions associated with obesity (5).

Improving dietary habits includes consuming balanced diet with appropriate portion sizes that meets the recommended levels of nutrients. Most Americans, specifically children, consume larger portion sizes than recommend while simultaneously meeting less than the recommended levels of nutrients to sustain health. For example, the average fiber intake for children and adults in the United States is less than half of the recommended levels. Fiber is a polysaccharide found in plants that is not digested or absorbed in the small intestine. Foods such as fruits, vegetables and whole grains provide a good source of dietary fiber to promote health. Fiber has many health benefits including promoting the growth of beneficial intestinal bacteria and decreasing the risk of developing coronary heart disease, stroke, hypertension, diabetes, and certain gastrointestinal disorders. However, fiber also decreases the risk of developing obesity and has been used to aid in weight loss. Clinical trials tracing back to 50 years show the use of fiber supplements to aid in weight loss. Researchers noticed high-fiber foods were more filling than low-fiber foods. Consuming foods with soluble and viscous fiber delay

gastric emptying which promote satiety. By promoting satiety, consuming fiber aids in regulating food intake (6).

The increasing incidence of obesity in the United States indicates a growing need for extensive research to discover ways to prevent and treat obesity. Studying the possible causes of childhood obesity is important in the dietetics field because of the increasing number of overweight and obese children. Discovering all the possible causes of childhood obesity will allow a dietitian to provide a comprehensive prevention or treatment plan for a specific child. As the obesity rates continue to increase, the levels of fiber intakes among children in the United States remains low. Consequently, studying the relationship of fiber intakes to children's BMI may reveal one the many ways to prevent and treat childhood obesity and save the lives of those suffering. If fiber intakes among children below the recommended Adequate Intake (AI) are positively correlated with higher BMI values, the correlation may suggest increasing fiber intakes among children may decrease the risk and incidence of obesity.

Related Research

Researchers have explored a variety of possible causes of the obesity epidemic in the United States. To implement appropriate prevention programs for children, it is important to be knowledgeable of the many factors causing obesity. Researchers have stated the best way to attempt to reverse the obesity epidemic is through prevention by integrating healthy lifestyle habits by increasing physical activity and improving dietary habits(4). A component of poor dietary habits among children is low intake of fruits, vegetables, and whole grains consequently leading many children to consume less than the recommended levels for fiber intake. Researchers have discovered the many

gastrointestinal health benefits of consuming dietary fiber, especially during childhood. Foods high in fiber require more chewing which triggers satiety signals, slowing gastric emptying, and allowing the brain to realize when the stomach is full. An inverse relationship between dietary fiber and obesity rates are seen through observations of countries where individuals are consuming high amounts of fiber and have lower obesity rates than the United States. However, very little data has been collected in the United States associating low fiber diets and increased risk of childhood obesity (7).

Numerous research studies have shown the beneficial role fiber plays in satiety and weight management among adults. Data collected from studies funded by the National Institute of Health examined self-reported dietary energy density among overweight, normal weight, and weight loss maintainers (10). Individuals maintaining weight loss self reported low dietary fat and higher dietary fiber intake than the overweight and normal weight groups. Therefore, increasing intakes of low energy density foods with fiber by consuming vegetables and whole grains promotes satiety and is shown to aid in maintaining weight loss. In a prospective cohort study of European adults, a statistically significant inverse relationship between dietary fiber and weight/waist circumference was found. Individuals consuming high fiber diets had a lower weight and smaller waist circumference than those consuming low fiber diets. The results from the two studies support the beneficial role of fiber intake in maintaining a healthy body weight, promoting weight loss, and preventing weight gain (13).

While higher amounts of fiber intake promote weight loss and weight maintenance, consuming low amounts of fiber can lead to a higher risk of developing obesity. Data collected from adults in the Continuing Survey of Food Intakes showed

only 5% of participants were consuming the AI for fiber for their age group. In women, a low-fiber, high-fat diet was strongly associated with an increased risk of becoming overweight and obese compared to those consuming a high-fiber, low-fat diet (14). In a 12 year prospective study of middle-aged women, women who had low intakes of high fiber foods were 50% more likely to gain weight than women who consumed high fiber foods over time. Women who consumed more whole grains consistently weighed less over the 12 year period than women who consumed less whole grains. Once again, weight gain was inversely associated with the intake of high fiber whole grain foods. The study also showed a positive relationship between the intake of refined grain foods and weight gain. Refined grain products do not contain the fiber found in whole grain foods, therefore consuming whole grain foods is important in weight maintenance (15).

While many studies have shown the benefits of fiber intake in weight maintenance among adults, fewer studies have been conducted regarding fiber and weight maintenance among children. As the childhood obesity rates increase, the total consumption of carbohydrates among children has increased. However most of the carbohydrates are in the form of low fiber refined grains. One common result among the data from the studies shows that the average fiber intake among children is significantly lower than the current Dietary Reference Intake (DRI) for their age group. Some studies show evidence of an inverse relationship between intakes of high fiber and fat intake, weight, adiposity, and waist circumference.

In the Feeding Toddlers and Infants Study of 2008, a cross-sectional study of a national random sample of United States children from birth through about age 4 years old measured nutrient intakes. The results showed dietary fiber was low in the majority of

toddlers and preschoolers and saturated fat intakes exceeded the recommended amount. If the children from the study continue to consume low amounts of fiber and high amounts of saturated fat they will be at a higher risk of becoming overweight and obese during childhood (16). In a study of 109 overweight Latino children from ages 10-17 years old, the only dietary element associated with overall metabolic syndrome in the children was soluble fiber. Those who did not have metabolic syndrome consumed more grams of total fiber per 1,000 calories. The results suggest increasing soluble fiber could reduce central adiposity and improve over health of Hispanic children. Results also showed a significant inverse relationship between consumption of soluble fiber and waist circumference, suggesting higher amounts of fiber intakes may contribute to a smaller waist (17).

In a cross sectional survey, 24-hour dietary intake of five cohorts of 10 year olds and two cohorts of 13 year olds showed children who consumed more than 18 grams/day of fiber had a lower percentage of energy from fat and saturated fatty acid than children consuming less than 7 grams/day of fiber. Therefore, children who consume high amounts of fiber also consume lower amounts of fats, decreasing their risk of developing obesity. The results show a relationship between increased high fiber intake and a more healthy diet. Children who had high fiber intakes consumed a more balanced diet comprised of fruits and fruit juices, vegetables and soups, and breads and grains than children who had lower fiber intakes. Children with low fiber intakes consumed foods that were higher in fat — such as fats and oils, eggs, cheese, pork and beef — than those with higher fiber intakes (8). In preadolescent girls, an inverse relationship was reported between dietary fiber intake and adiposity. Girls consuming high amounts of fiber had less adipose tissue. Furthermore, an inverse correlation existed between dietary fiber and

dietary fat intake. The study suggests girls consuming a high fiber diet had lower adiposity but also consumed lower amounts of fat, leading to a decreased risk of obesity (9).

In a study of 54 overweight Latino adolescents, sugar and fiber intake were measured after a 16 week nutrition education intervention. Results showed adolescents who increased fiber intake improved their BMI and decreased visceral adipose tissue. By decreasing BMI and adipose tissue, the adolescents may have decreased their risk for continuing to be overweight through adulthood (18).

Overall, the results from the data suggest correlations between dietary fiber intake and weight status exist. Children in the United States are consuming less than adequate amounts of fiber to promote health benefits to prevent obesity. Increasing children's fiber intake through consumption of fruits, vegetables, and complex carbohydrates will lead to a more balanced diet and even possibly prevent the incidence and risk of obesity.

Objectives of the Study

Childhood obesity rates have risen considerably in recent decades in the United States. Dietary intakes of children have also shown several areas for improvement. The purpose of this study is to examine the relationship between fiber intakes and obesity in US children. To assess this relationship, the following research questions will be explored:

- Is total fiber intake correlated with the BMI of children?
- Do age differences exist in the total fiber intakes among children by obesity status?

- Do differences exist in the adequacy of fiber intakes in children based on the current DRI's by obesity status?

Procedures

a. Design

Data from 1999-2008 National Health and Nutrition Examination Survey (NHANES) was used to assess the relationship between total fiber intake among children and their BMI. NHANES is a program of studies used to evaluate nutritional and health status in the United States. The survey collects health and nutrition measurements of approximately 5,000 individuals a year in counties across the country. The survey includes interviews regarding demographics, socioeconomic, dietary, and health related questions. In addition to the interviews, highly trained professionals conduct medical and dental examinations, as well as collecting physiological measurements. Information from the survey is used to determine nutritional status and it's relation to health promotion and disease prevention. The results from the NHANES surveys are used to set national standards for height and weight.

NHANES carefully oversamples specific populations to produce adequate sample sizes for reliable representation in statistical analyses. Over sampling of individuals of Hispanic ethnicity, children, adolescents, elderly, and pregnant women ensure the sample is truly representative of the adults and children in the United States. Data from the NHANES surveys are used by agencies such as the Food and Drug Administration to assess program activities such as vitamin and mineral fortification regulations. As a result of the NHANES surveys many beneficial strides have been made in improving the knowledge and awareness of the trends of many health issues in the United States. The

prevalence of overweight and obese individuals in the studies have led to the implementation of programs focusing on diet and exercise and have provided a way to evaluate trends in obesity (11).

b. Population and Sample

We examined data from children by three different age groups: 2-5, 6-11, 12-18 years of age. Information including dietary intake and BMI status from 1999-2008 NHANES surveys was used.

c. Data Collection and Preparation

The household interviews conducted of individuals 16 years of age and older were interviewed in person to collect demographic data. All survey participants who have a household interview record have a demographics file record providing family and individual level information. The file includes variables on gender, age, race/ethnicity, education level, marital status and household income. However, for those participating under the age of 16 years had assistance from another individual in providing information for the survey.

Dietary intakes of the NHANES participants have been collected. The participants are eligible for two 24-hour dietary recall interviews. The first interview is conducted in person at the Mobile Examination Center and the second interview is conducted by telephone. For consistency in collection and the lower rates of completion of the telephone interview, only the first day of dietary recall was used for these analyses. A 24-recall was used estimate the consumption of food and beverages, as well as intakes of energy, nutrients, and other food components. A proxy is used for young children who are unable to recall or answer specific dietary questions. A proxy always responded for a

child under the age of 6 years and the child does not need to be present for the interview. For children between the ages of 6-8 years, a proxy was used to be the primary responder but the interview occurred with the child present and may have interjected to provide further dietary information. The proxy for any child under 9 years old may be anyone who is knowledgeable about the child's dietary intake. For ages 9-11 years old the child will be the primary respondent but will be assisted by an adult. In some cases the proxy may not be able to provide information about food eaten at school or at daycare so information is dependent upon the child's response.

To determine if children have met the recommended intake of fiber, we computed a percentage of their estimated intakes compared to the recommended levels. The percent of recommended intake equaled fiber intake (grams/day) divided by the Adequate Intake (AI) for the specific age group multiplied by 100. To classify adequacy of fiber intakes, if the percentage is below 100% of the AI, the child was categorized as not meeting the recommended intake of fiber using the current AI for total fiber (grams/day) in the table below (12).

Age Group (years)	Male (grams/day)	Female (grams/day)
1-3	19	19
4-8	25	25
9-13	31	26
14-18	38	26

Age and Gender-based Adequate Intakes for Fiber (g)

To assess the weight status of children, NHANES collects body measurements used to examine the associations between body weight and health and nutrition status and to estimate the prevalence of overweight and obesity in the United States population. We used the body measurements of height and weight to compute BMI status. We generated

BMI (kg/m²)	Classification
< 5 th	Underweight
5-85	Healthy Weight
85-95	Overweight
>95	Obese
Weight status classifications for children based on BMI-for-age-percentiles from the CDC growth charts	

BMI for age percentiles using EpiInfo and recode our results into obesity categories listed in the table.

d. Instrumentation and data analysis

We analyzed data from

NHANES to determine if total fiber intake is correlated with the BMI of children. We generated the mean total of energy adjusted fiber (grams/1,000 kcals) intakes and calculated the percent of AI for fiber by age group and weight status. These percentages determined if children have met their recommended dietary needs. We used a Pearson correlation to determine if a relationship exists between BMI-percentile and fiber intake among children. The computed R value signified the direction and strength of the correlation between fiber intake and BMI status.

Analysis of variance (ANOVA) was used to compare differences in mean fiber intakes and percent of AI by age and BMI status. Chi Square was used to compare differences in the proportion of children meeting AI for fiber by age and BMI status. Results from ANOVA and Chi Square determined if there are age differences in total fiber intakes among children by obesity status.

The data were tabulated for analysis using SPSS (version 19.0). All of the analyses were conducted using the SPSS Complex Samples (version 19.0) to account for the stratified, multi-staged sampling technique used in subject selection.

Facilities and/or Resources and Equipment Needed

The data analysis was performed in Dr. Taylor's laboratory, which contained the software necessary to analyze the complex survey data.

Results

Correlation of fiber intake with BMI

Data was analyzed to assess the correlation of fiber intake in grams and BMI percentile for all age groups. Table 1 presents the findings from the data correlation. 12-18 year olds had significantly ($p < 0.001$) higher total fiber intakes in comparison to 2-5 and 6-11 year olds. The 12-18 year olds also had a significant ($p < 0.001$) higher % of fiber adequate intake met than 2-5 and 6-11 year olds. There was no significant difference in the energy adjusted fiber intake among the age groups.

Table 1: Relations of fiber intakes to BMI percentile by age

Fiber Intakes	R	P
Total fiber (g)		
Total	0.026	0.125
2-5 yr	0.062	.083
6-11 yr	0.023	.444
12-18 yr	0.119	<0.001
Energy-adjusted fiber (g/1,000 kcals)		
Total	0.025	0.246
2-5 yr	0.009	.818
6-11 yr	0.022	.382
12-18 yr	0.025	.407

Percent of need (% of Fiber AI)		
Total	0.039	0.040
2-5 yr	0.047	.157
6-11 yr	0.020	.538
12-18 yr	0.121	<0.001

Differences in mean fiber intake by obesity status and age group

When analyzing if differences exist in BMI categories for the three age groups, there was a significant difference between the total fiber and energy-adjusted fiber intakes in the 2-5 and 12-18 year olds between normal weight, overweight, and obese children.

Table 3: Differences in mean fiber intake by obesity status age group

Age Groups	BMI Categories	Total Fiber	Energy-adjusted	P Value
2-5 yrs.	Normal Weight (5-<85th)	10.8 (0.22)	6.9 (0.13)	0.031
	Overweight (85-<95th)	12.4 (0.51)	7.3 (0.24)	
	Obese (>=95th)	11.1 (0.47)	6.5 (0.21)	
6-11 yrs.	Normal Weight (5-<85th)	13.4 (0.3)	6.7 (0.15)	0.741
	Overweight (85-<95th)	13.4 (0.52)	6.8 (0.22)	
	Obese (>=95th)	13 (0.44)	6.4 (0.2)	
12-18 yrs.	Normal Weight (5-<85th)	14.8 (0.28)	6.4 (0.14)	<0.001
	Overweight (85-<95th)	12.8 (0.46)	6.1 (0.16)	
	Obese (>=95th)	12.7 (0.68)	6.4 (0.26)	

Differences in the adequacy of fiber intakes by obesity status

In analyzing the differences in % of adequate intake met by BMI within each age group, there was a significant ($p = 0.026$) difference in the 6-11 years for need met.

Table 4: Differences in % of AI met by BMI within age groups

Age Groups	BMI Categories	% not meeting AI	P Value
2-5 yrs.	Total	95.4%	0.150
	Normal Weight (5-<85 th)	96.0%	
	Overweight (85-<95 th)	91.8%	
	Obese (≥ 95)	95.3%	
6-11 yrs.	Total	95.8%	0.026
	Normal Weight (5-<85 th)	95.0%	
	Overweight (85-<95 th)	97.4%	
	Obese (≥ 95)	97.8%	
12-18 yrs.	Total	95.1%	0.174
	Normal Weight (5-<85 th)	94.1%	
	Overweight (85-<95 th)	95.8%	
	Obese (≥ 95)	97.0.%	

Discussion

In this study, we examined the relationship between fiber intakes and obesity in U.S. children. We hypothesized a relationship between fiber intake and BMI in children and explored questions regarding total fiber intake, energy-adjusted intake, and adequacy of fiber intakes in children based on the current DRI's. Researchers have explored a variety of possible causes of the childhood obesity epidemic in the United States and have stated the best way to attempt to reverse the obesity epidemic is through prevention by integrating healthy lifestyle habits by increasing physical activity and improving dietary habits(4). In order to improve dietary habits among children, it is important to gauge a general idea of the quality of their diet as present. Our findings show 95% of

children not meeting their DRI for fiber intake which is consistent with research that has shown a major component of poor dietary habits among children is low intake of fruits, vegetables, and whole grains which are all high in fiber content. In addition, our findings were similar to data collected from adults in the Continuing Survey of Food Intakes showed only 95% of participants were not meeting their AI for fiber for their age group(14).

Our findings showed a significant ($p = 0.040$) linear relationship of percent of adequate intake of intakes and BMI percentiles across all age groups. These results account for less than 2% of the variance and suggest children who are meeting a higher percentage of their fiber needs based on adequate intake have a healthier BMI. However, no significant p values indicating no plausible linear relationship between total fiber intakes or energy-adjusted intakes and BMI percentiles. Even though our findings suggest a lack of significant relationship for total fiber and energy-adjusted fiber intakes, the results may have been affected by the overall low total fiber intakes across all age groups leading to a lack of variability in the data available in order to analyze the relationship. Even though the p value is not significant, the r value shows a small positive relationship between fiber intake and BMI. A more variable data set including high and adequate intakes of fiber among children may be necessary in order to detect a stronger positive relationship.

In assessing the relationship between fiber intake and BMI in children, our findings are consistent with the research on the relationship of fiber intake and BMI in adults. Our findings showing a statistically significant relationship ($p=0.040$) between the percent of adequate fiber intake and BMI are consistent with findings through

observations of countries where adults are consuming high amounts of fiber and have lower obesity rates than the United States (7).

When comparing differences between mean fiber intakes by age groups, 12-18 year olds had significantly ($p<0.001$) higher total fiber intakes and % of fiber adequate intake met than 2-5 and 6-11 year olds. Even though 12-18 year olds are eating more fiber compared to the younger age groups, they are not eating more fiber per caloric intake. The data suggests that they may just be eating more fiber as a result of consuming more calories. However, the data suggest 12-18 year olds are more likely to be more adequately meeting their fiber needs.

When analyzing if differences exist in BMI categories for the three age groups, there was a significant difference between the total fiber and energy-adjusted fiber intakes in the 2-5 and 12-18 year olds between normal weight, overweight, and obese children. Individuals 12-18 year olds falling within a normal weight category had significantly higher fiber intakes than those who were overweight and obese. Our findings suggest an association between children between 12-18 years old with higher fiber intake and maintaining a normal weight range. These results are consistent with a study of middle-aged women; women who had low intakes of high fiber foods were 50% more likely to gain weight than women who consume high fiber foods over time. Once again, weight gain was inversely associated with the intake of high fiber whole grain foods (15). Overall, 12-18 year olds are consuming significantly less energy adjusted fiber than those 11 years and younger. Obese children in 12-18 year olds have significantly lower energy adjusted fiber intakes. Our findings show fiber intakes are far below the recommended levels in all groups and by weight status. There is little relationship of fiber

intakes to obesity, possibly due to the low variability in fiber intakes across age groups and BMI percentiles.

In analyzing the differences by BMI status within each age group, the 6-11 year olds who are overweight and obese are significantly less likely meet a higher percentage of their AI than children at a normal weight. These data suggest that children who are more likely to meet a higher percentage of the AI need are more likely to maintain a healthier weight. The data also supports that once again we have lacking variability across the board, as approximately 95% of children are not meeting their recommended level of fiber needs. These data suggest a pressing need for the increased consumption of fiber intakes for all age groups.

Conclusion

Overall, the results from our study suggest correlations and relationships between dietary fiber intake and BMI. A data set including more variability regarding the dietary fiber intakes may present a more clear indication of the strength of the relationship between fiber intake and BMI. Our data show children in the United States are consuming significantly less than adequate amounts of their daily fiber recommendations to promote health benefits and prevent obesity. Our research suggests the need for detailed education and interventions to help increase the amount of fiber consumed by the youth of Americans. As children age they began to develop more power, choice, and access to food supply which influences their decision making. Increasing children's fiber intake through consumption of fruits, vegetables, and complex carbohydrates will lead to a more balanced diet and even possibly prevent the incidence and risk of obesity.

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